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CABLE LOGGING IMPACTS ON SOILS ON THE ALLEGHENY PLATEAU[1]

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ABSTRACT

Soils are always disturbed during logging operations. In highly disturbed roads, landing, and permanent skid trails, land is taken out of production for at least a rotation. Less severe surface disturbance such as compaction, scarification, and rutting may lead to off-site impacts from soil erosion and stream sedimentation or on-site impacts of lowered soil fertility and impaired water relations that impede seedling establishment or reduce growth of residual trees. Cable logging reduces or avoids disturbance by eliminating equipment such as rubber-tired skidders from sites.

I compared the severity of soil disturbance on cable logged versus conventionally logged sites on steep slopes on the Allegheny Plateau. Two commercial timber sales on the Allegheny National Forest in McKean County provided a comparison where soils and slopes were similar. Area of soil disturbance was estimated by systematically sampling along transects in three stands coventionally harvested, and three stands harvested using a skyline cable system. There was minimal soil disturbance on sites logged with cable equipment. The amount of land disturbed along the in-haul path was much less than the area disturbed by skid trails in conventional logging. Over two-thirds of the area of the cable logged stands was undisturbed, as compared to less than one-third of the conventionally logged stands. Even where soil was disturbed along the main in-haul path and lateral in-haul paths, compaction was minimal. Compared to conventional logging on steep slopes, cable logging creates much less disturbance, with minimal effect on site quality.

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INTRODUCTION

As many as 800,000 acres of high quality hardwood forests in Pennsylvania are unsuitable for conventional thinning and harvesting operations because of steep slopes, poorly drained soils with seasonally high water tables, or ecologically fragile sites such as forested wetlands. Land managers are concerned about the adverse on- and off-site impacts resulting from soil disturbance caused by logging equipment.

Soils are always disturbed during logging operations. Highly disturbed roads, permanent skid trails, and landings represent land taken out of production for a rotation or longer (Kochendorfer, 1977). Less severe surface disturbance, such as rutting, scarification and compaction caused by rubber tired skidders and other conventional harvesting equipment, may lead to off-site impacts from soil erosion and stream sedimentation or on-site impacts of lowered soil fertility and impaired water relations that impede establishment and growth of seedlings or reduce growth of residual trees (Froelich, 1979; Froelich and McNabb, 1984).

The extent of disturbance caused by logging is influenced by the kind of equipment and the way it is used; the area devoted to roads and permanent skid trails; and the products removed—the size of individual trees, total volumes, and whether whole trees or just stems are removed (Tritton and Johnson, 1988). Cable yarding, in which logs are removed by a suspended cable system rather than by ground-based logging equipment operating on the site, may reduce soil disturbance. Cable yarding is proving to be a feasible technology for logging on the steep slopes and fragile sites of the Allegheny Plateau.

Current interest in cable logging in Pennsylvania has been limited to public land managers and the focus throughout the northeast has been to demonstrate technical and economic feasibility (Fairweather, in press; Durner, 1990; LeDoux, 1985; NYSERDA, 1986; Peters, 1982). I undertook this research to provide public land managers with information on the effects of cable logging on soils and possible environmental benefits, as compared to conventional logging of steep slopes on the Allegheny Plateau.

METHODS

Two commercial timber sales on the Ridgway District of the Allegheny National Forest provided a comparison of conventional and cable logging of sites with similar soils and slopes. The two timber sale areas were on opposite slopes overlooking the South Branch of Kinzua Creek in

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TABLE 1. Characteristics of the stands sampled from two commercial timber sales on the Ridgway District, Allegheny National Forest, McKean County, PA.

Location		Aspect	Slope	Area	Sawtimber volume	Pulpwood volume	Total volume[1]
Conventional			(%)	(acres)	(MBF/acre)[2]	(cords/acre)	(MBF/acre)
Gibbs Hill	13	ENE	35	10	11.2	5.2	13.8
	14	ENE	35	13	14.5	4.6	16.8
	15	ENE	35	17	9.6	8.9	14.1
Cable							
~~Shotgun~~	~~7~~	~~SW~~	~~35~~	~~10~~	~~10~~	~~17.9~~	~~19.0~~
	~~8~~	~~SW~~	~~45~~	~~10~~	~~6.8~~	~~10.3~~	~~12.0~~
	9, 11	SW	35	15	7.9	10.3	13.1

[1]Pulpwood volume converted to 1/4″ International Log Rule using the aproximation of 500 bd. ft. per cord.
[2]MBF/acre = thousand board feet per acre, 1/4″ International Log Rule

McKean County. Both areas were commercially clearcut. The Gibbs Hill sale was conventionally logged with rubber-tired skidders between July, 1987 and August, 1988. The Shotgun sale was logged between September, 1987 and July, 1988 with a skyline cable system which consisted of a truck-mounted, two-drum yarder and 40- foot tower with a manually set carriage.

Three stands in each sale area were sampled and their characteristics are summarized in Table 1. Slopes ranged from 35% to 45%. Soils of both sale areas were Hartleton (loamy-skeletal, mixed, mesic Typic Hapludults) on the upper slopes and Buchanan (fine-loamy, mixed, mesic Aquic Fragiudults) at lower slope positions (Churchill, 1987). Individual stands ranged from 10 to 17 acres. Stand volumes before harvest ranged from 12,000 to 19,000 board feet per acre (Table 1). Stands in both sale areas were typical Allegheny Hardwood types (Table 2).

Area of soil disturbance was estimated in each stand by systematically examining 100 points along a transect that followed slope contours roughly perpendicular to logging activity. Points were approximately 25 feet apart. Each point was placed in one of three disturbance classes, according to the method described by McMinn (1984):
Class 1—Undisturbed; duff or litter covers the surface.
Class 2—Exposed; litter and duff have been scraped away exposing mineral soil, without scarification.
Class 3—Dislocated; mineral soil exposed and scarified or dislocated.

A log-linear model was fit to the 2 by 3 contingency table using the SYSTAT microcomputer-based statistical analysis software package (Wilkinson, 1988). The Pearson Chi^2 statistic was used to test for independence. Significance tests were at the 0.01% level.

RESULTS

There was minimal soil disturbance on sites logged with cable equipment (Figure 1). On average, only 4% of the area in these stands was in the most disturbed Class 3 (dislocated) as compared to 32% of the area in the conventionally logged stands. Over two-thirds of the area of the cable logged stands was undisturbed (Class 1), compared to less than one-third of the conventionally logged stands. The Pearson Chi^2 with two degrees of freedom was 134.9, indicating that the amount of disturbance of the two logging methods was significantly different. Even when the results are collapsed into only two classes, disturbed versus undisturbed, cable yarding shows significantly less disturbance (Table 3).

The area disturbed along in-haul paths of cable logged stands (Figure 2) was estimated by measuring the width at several points along the path. The average width of disturbance was 6 feet, but disturbance was not evident along the entire length of the path. The occurrence of disturbance likely was influenced by the shape of the slope and was evident on convex, bench-like features associated with old windthrow mounds. Along much of the path, however, soil was undisturbed. In areas along streams, where full suspension of logs was required by conditions of the sale (S. Wingate, USFS Ridgway, pers. comm., 1989), no disturbance was detected within 10 to 20 feet of either side of the streams.

TABLE 2. Species distribution of pre-harvest sawtimber volume on the stands logged conventionally (*Gibbs Hill 13, 14, and 15*) and the stands harvested with a cable system (Shotgun 7, 8, and 9+11).

	Location					
	Gibbs Hill			Shotgun		
Species	13	14	15	7	8	9,11
	Volume (MBF/acre[1])					
Black Cherry *Prunus serotina* Ehrh.	5.1	6.5	3.4	2.5	3.5	4.3
White Ash *Fraxinus americana* L.	0.1	0.3	1.1	1.1	1.5	1.0
Sugar Maple *Acer saccharum* Marsh.	3.4	4.8	3.4	3.6	1.2	1.4
Red Maple *Acer rubrum* L.	0.1	0.7	0.2	1.3	0.3	0.3
American Beech *Fagus grandifolia* Ehrh.	1.9	1.5	0.5	1.5	0.3	0.9
Basswood *Tilia americana* L.	0.4	0.7	1.0	—	—	—
Yellow Poplar *Liriodendron tulipifera* L.	0.2	—	0.1	—	—	—

[1]MBF/acre = Thousand board feet per acre, 1/4″ International Log Rule

DISCUSSION

The most obvious damage that can be avoided by using cable logging on steep slopes is the amount of land severely disturbed by skid trails. On steep slopes over 35%, skid trails in conventional logging operations must be located close together to minimize travel across slope by equipment. Kochendorfer (1977) found skid trails as close as 150 ft. apart in West Virginia. Because skid trails are highly compacted and often rutted, this is land taken out of production during the next rotation. What is more, accelerated erosion is likely from these trails. Even with seasonal restrictions imposed to reduce the impacts of harvesting during wet soil conditions on the Gibbs Hill sale, erosion and sedimentation were observed (S. Wingate, USFS Ridgway, pers. comm., 1989).

Less obvious disturbance by skidders in conventional logging comes from soil compaction that does not disturb the surface but may affect future productivity. Even one pass of a skidder tire can cause compaction on some soils (Froelich, 1979; Froelich and McNabb, 1984) and large areas of a stand can be affected by compaction disturbance during conventional logging. L.R. Auchmoody (USFS Warren, pers. comm., 1989) observed 85%-90% of a stand run over by skidders during conventional logging, although the entire ground surface under the skidder was not necessarily affected. Unfortunately, a reliable way to measure these effects under operational conditions does not exist. Some portion of the "undisturbed" sample points in the Gibbs Hill stands were probably affected by this subtle form of disturbance.

Cable logging disturbed significantly less soil than conventional logging on steep slopes in these stands on the Allegheny Plateau. These results are in accord with results of studies from other areas of the country (McMinn, 1984) Even where soil was disturbed along main in-haul and lateral in-haul paths (Figure 2), rutting and compaction were minimal. Compared to conventional logging on steep slopes, cable logging creates much less disturbance and should have minimal effect on site quality and future stand productivity as well as much less potential for off-site environmental impacts.

TABLE 3. Contingency table analysis of logging impacts.

	Disturbance Class		
Logging Type	Undisturbed	Disturbed[1]	Total
Conventional[2]	83	217	300
Cable[2]	213	87	300
Total	296	304	600

Pearson Chi^2, 1 Degree of Freedom = 36.98, Probability <0.001

[1]Disturbed represents both Disturbance class 2 (Exposed) and Disturbance Class 3 (Dislocated).
[2]Data are based on 100 sample points in each stand.

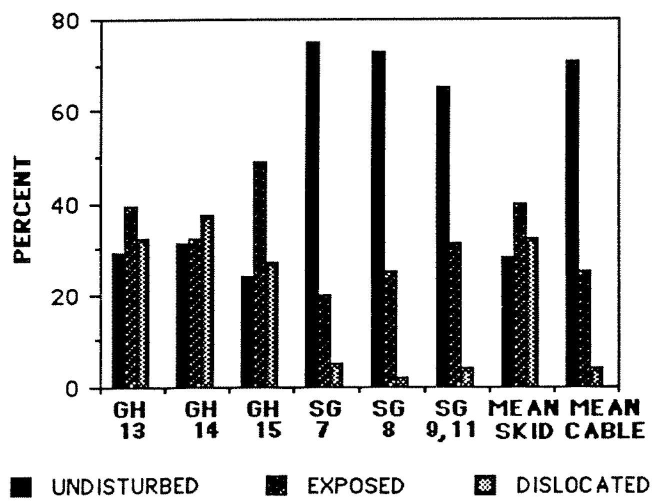

FIGURE 1. Area of soil disturbance in each stand, expressed as the percentage of sample points in each disturbance class.
(GH = Gibbs Hill, SG = Shotgun).

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FIGURE 2: Soil disturbance from cable logging is greatest along the main in-haul path but even here, rutting and compaction are minimal.